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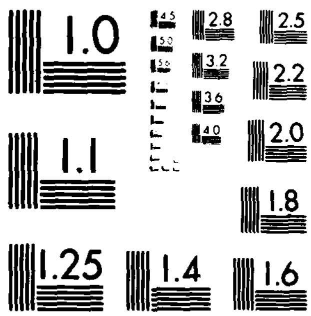

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TECHNICAL NOTE

MRL-TN-461

REFLECTIVITY OF HESSIAN-COVERED TARGETS

AT A WAVELENGTH OF 1060 nm

G. Bullock

Approved for Public Release

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ABSTRACT

The optical characteristics of hessian were investigated in order to determine its suitability for covering targets in laser-guided-bomb trials. Incoherent light at a wavelength of 1060 nm was used to measure the reflectance of a painted target, with and without hessian covering. The effect of hessian in suppressing the glint from a highly reflecting spherical surface was also investigated. The results indicate that the reflected light from a hessian-covered target is more intense for all viewing angles than the reflected light from a painted target. Hessian covering is shown to be sufficiently dense to be effective in suppressing glint. Although the measurements were made with incoherent light, it is believed that the results are applicable to laser illumination.

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The optical characteristics of hessian were investigated in order to determine its suitability for covering targets in laser-guided-bomb trials. Incoherent light at a wavelength of 1060 nm was [illegible] to measure the reflectance of a painted target, with and with[illegible] sian covering. The effect of hessian in suppressing the glint fro[illegible] y reflecting spherical surface was also investigated. The results indica[illegible] at the reflected light from a hessian-covered target is more intense for all viewing angles than the reflected light from a painted target. Hessian covering is shown to be sufficiently dense to be effective in suppressing glint. Although the measurements were made with incoherent light, it is believed that the results are applicable to laser illumination.

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CONTENTS

REFLECTIVITY OF HESSIAN-COVERED TARGETS AT A WAVELENGTH OF 1060 nm

1. INTRODUCTION

This Technical Note presents the results of experiments conducted in response to a Royal Australian Air Force Task, AIR 81/009. The request to these Laboratories from the RAAF came after laser-guided-bomb (LGB) trials were conducted in Western Australia early in 1981. Wrecked car bodies were used as targets and, during the trials, standard-issue RAAF hessian was draped over the target car bodies to avoid possible eye damage to observers and pilots due to stray specular reflections, or glints. A ground-based pulsed-laser designator, operating at a wavelength of 1060 nm, illuminated the targets. It was observed that some LGBs behaved as if the scattered radiation from the target had not been detected. In order to determine whether the hessian covering was responsible for this behaviour, the relevant optical characteristics of hessian were investigated, and the results are presented in this Technical Note.

2. APPARATUS

The apparatus used in the investigations is shown in Fig. 1. The target was illuminated by an incandescent light source, which was interrupted by a 130-Hz chopping disc. This chopping disc also provided a reference signal for the phase sensitive detector (PSD). The light incident on the target could be polarised by the insertion of a piece of infrared polarising film.

The use of an incoherent source eliminated variations in scattered intensity with angle (speckle) that would have occurred with a coherent (laser) source. In most applications of laser designators which involve relative motion between laser, target and LGB, the speckle would be changing very rapidly. In those circumstances, the LGB would respond only to an average value of scattered laser radiation which would be equivalent to that measured with the incoherent source used here.

The detector used was a silicon photodiode, type SGD-100, which was aligned behind a 45-mm diameter, 75-mm focal length lens and a narrow-band optical filter with a bandwidth of about 10 nm. The illuminated area on the target was completely contained within the field of view of the detector. Measurements were made with several filters centred around the laser wavelength of 1060 nm to confirm that the results were not strongly wavelength dependent for any of the targets examined. Typical signal levels after the photodiode preamplifier were 3 mV RMS, which comfortably exceeded the circuit background noise of about 200 μV RMS. Phase sensitive detection was used for all measurements. Details of the detector circuit are included in Fig. 2.

In operation, the detector assembly was moved around a 5-m radius arc, centred on the target, over a viewing-angle range of 0° - 90°. At each position, the detector was carefully aligned to maximise the signal on the PSD. The light source, the detector and the normal to the plane of the target were all in the same horizontal plane. Light incident on the target uniformly covered an area 130 mm by 130 mm, which is large compared with the weave dimensions in the hessian. Calibration of the apparatus was effected by use of a standard white diffuse reflector with a known reflectance of 91 percent.

3. TARGET MATERIALS

The hessian used in the measurements presented here was obtained from RAAF No. 1 Stores Depot, Tottenham. Other grades of hessian from different sources were tried in preliminary experiments and found to behave similarly.

The two backgrounds covered with the hessian were chosen to represent essential features of car body targets used in trials. They comprised a painted flat metal plate and a highly reflective spherical segment. The flat metal plate was painted with a typical dark drab-olive camouflage paint which had an enhanced infrared reflectance. To simulate a hessian-draped car body, the plate was closely covered with a single layer of hessian. The spherical segment was a 2.4-m radius glass spherical cap which had been aluminised to produce a mirror-like surface. This target simulated the highly reflective curved surfaces often present on car bodies.

4. MEASUREMENTS

The effectiveness of the hessian as a covering was determined by measuring its transmittance to 1060-nm radiation as a function of incidence angle. The results are shown in Fig. 3.

The painted target, with and without hessian covering, was illuminated both at normal incidence and at an angle of 30° to the normal. Values of reflectance as a function of viewing angle for these two conditions are plotted in Figs. 4 and 5 respectively. The painted plate, with and without hessian covering, was also illuminated with polarised light to assess the effect of a polarised laser beam. Results for vertically polarised light are shown in Fig. 6 and those for horizontal polarisation in Fig. 7.

The reflected intensity from the spherical reflector was approximately constant for the range of angles within which an image of the source was visible in the reflector. A hessian covering produced a greater than tenfold reduction in intensity at all angles within this range.

5. DISCUSSION OF RESULTS

5.1 *Hessian Transmittance*

As shown in Fig. 3, the transmittance of the standard hessian was less than 7 percent at normal incidence, and decreased further for oblique angles. Hence the infrared light reflected from a hessian-covered target would be expected to be almost independent of the nature of the underlying surface. Results obtained in this investigation support this expectation and confirm that the use of hessian covering is an effective method of reducing glints from underlying reflective surfaces. Although this effect can reduce the reflected light available to a LGB, it is probably not relevant to LGB performance since military targets, for which the LGB would be designed, rarely have highly reflective surfaces.

5.2 *Reflectance*

The results of reflectance measurements are shown in Figs. 4-7. In these graphs, 100-percent reflectance represents the intensity of reflected light that would be obtained from a perfect white diffuse reflector if it were illuminated and viewed at normal incidence. The apparatus used here maintains the illuminated target area within the field of view of the detector and therefore the measured intensity of scattered light from a perfect diffuse reflector would decrease as the cosine of the viewing angle, which is characteristic of a Lambertian surface.

5.2.1 *Unpolarised Light at Normal Incidence*

Figure 4 compares the reflectances of the painted target and the hessian-covered target, both illuminated at normal incidence with unpolarised light. The painted target exhibited a lower maximum reflectance than the hessian-covered target, and the painted-target reflectance decreased more rapidly as the viewing angle increased. The distribution of light from the painted surface followed an approximate Gaussian form (i.e. varied as $\exp(-KA^2)$, where A is the viewing angle and K a constant) which is expected from a specularly reflecting surface with random, normally distributed values of surface angle about the mean surface. The hessian-covered target behaved approximately as a 50 percent diffuse reflector with the expected Lambertian (cosine) variation of intensity with viewing angle. The reflected light from the hessian-covered target was more intense at every viewing angle than the reflected light from the painted target.

5.2.2 *Unpolarised Light at Oblique Incidence*

Figure 5 compares the reflectances of the painted target and the hessian-covered target when both were illuminated obliquely with unpolarised light incident at 30° to the target surface normal. The peak reflectance of the painted target occured at 60° viewing angle, which would be expected for a combination of specular and weak diffuse reflectance components. Again, the distribution is approximately Gaussian. The reflectance of the hessian-covered target exhibited a very broad peak around 30° viewing angle, which is consistent with behaviour as a 50 percent diffuse reflector. At all viewing angles, the hessian-covered target reflected more light than the painted target.

5.2.3 *Polarised Light at Oblique Incidence*

Figure 6 compares the reflectances of a hessian-covered target and a painted target when illuminated with vertically polarised light incident at 30° to the target surface normal. The hessian-covered-target results were similar to those in Fig. 5, as expected for a diffuse reflector. The slight shift in peak reflectance was due to the increased reflectance of the underlying painted surface when vertically polarised light was used. The curve for the painted target shows an increased peak reflectance since vertically polarised light was obliquely incident on a vertical, partially specular surface. Figure 7 compares the reflectances of the two targets when obliquely illuminated with horizontally polarised light. The hessian covered target results were similar to those obtained in Figs. 5 and 6. The painted target showed a marked decrease in reflectance due to the unfavourable combination of horizontally polarised light obliquely incident on a vertical surface.

6. CONCLUSIONS

The reflectance of a painted target, with and without hessian covering, has been measured for illumination with incoherent light at a wavelength of 1060 nm. The effect of hessian in suppressing the glint from a highly reflecting spherical surface has also been investigated.

Although the range of conditions under which measurements were made was not exhaustive, the results indicate that a hessian-covered target has similar reflectance characteristics to those of a 50-percent diffuse reflector. The reflected light from the hessian-covered target was more intense at every viewing angle than the reflected light from the painted target. Hessian covering is sufficiently dense to be effective in suppressing glint.

Although the measurements were made exclusively with incoherent light, it is believed that, under practical conditions, the results are applicable to laser illumination.

7. ACKNOWLEDGEMENT

The author wishes to thank C.H.H. Carmichael for his assistance both with the design of the experiment and in the preparation of this Technical Note.

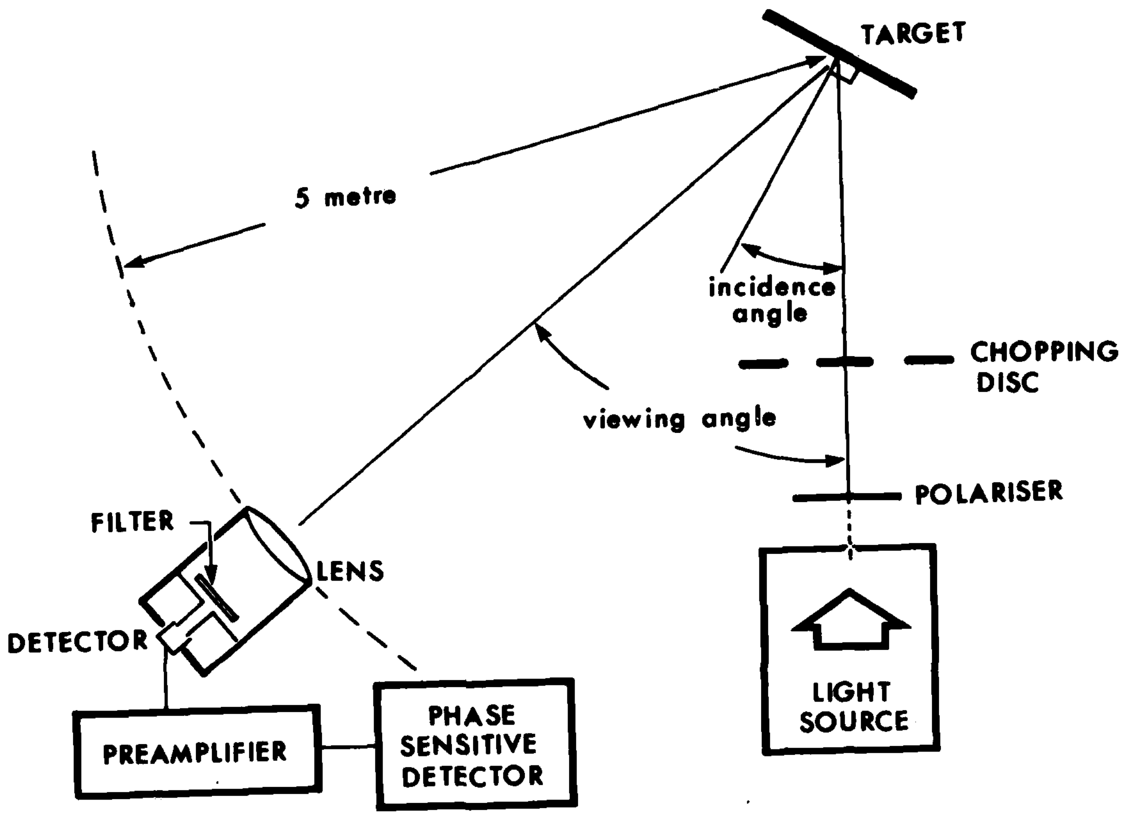

FIG. 1 - Apparatus used in the investigations.

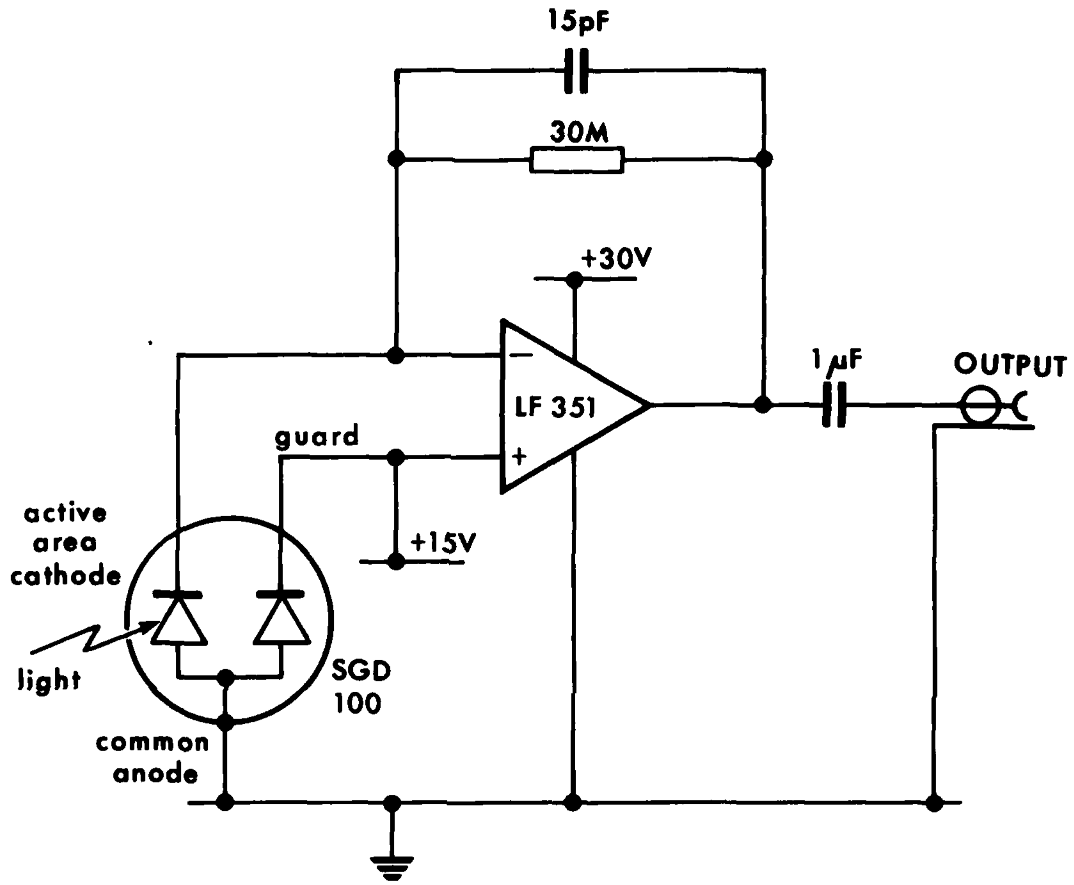

FIG. 2 - Detector Circuit

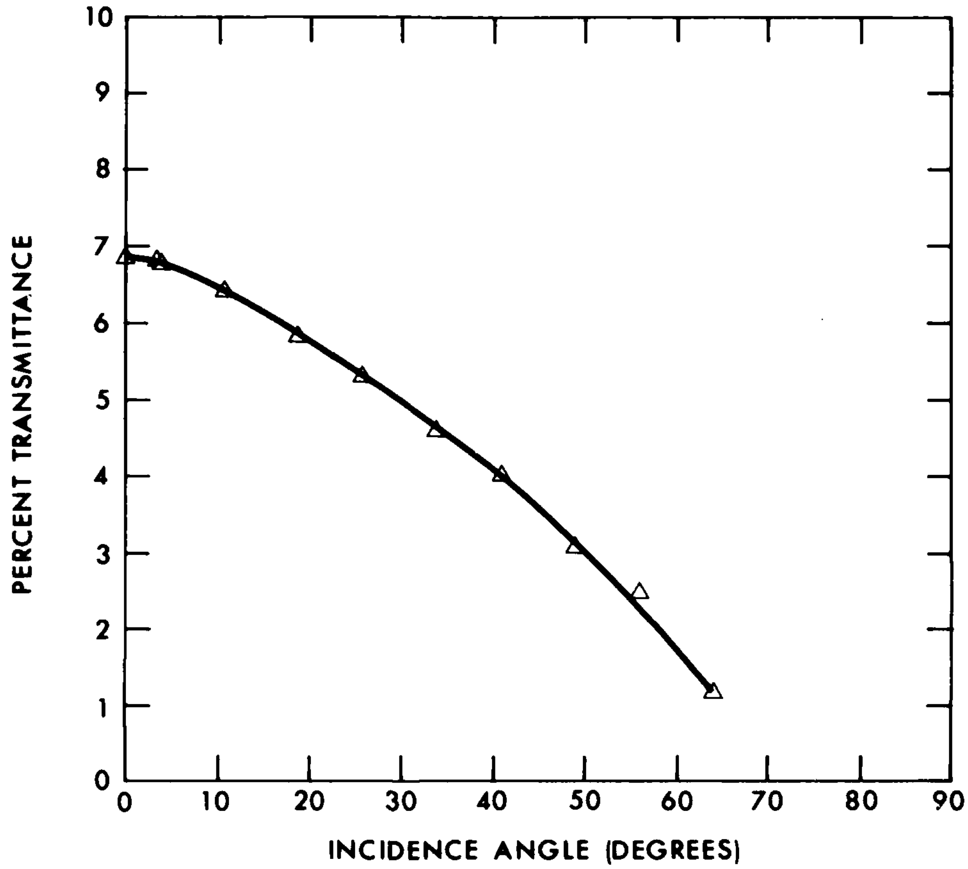

FIG. 3 - Transmittance of hessian as a function of angle of incidence.

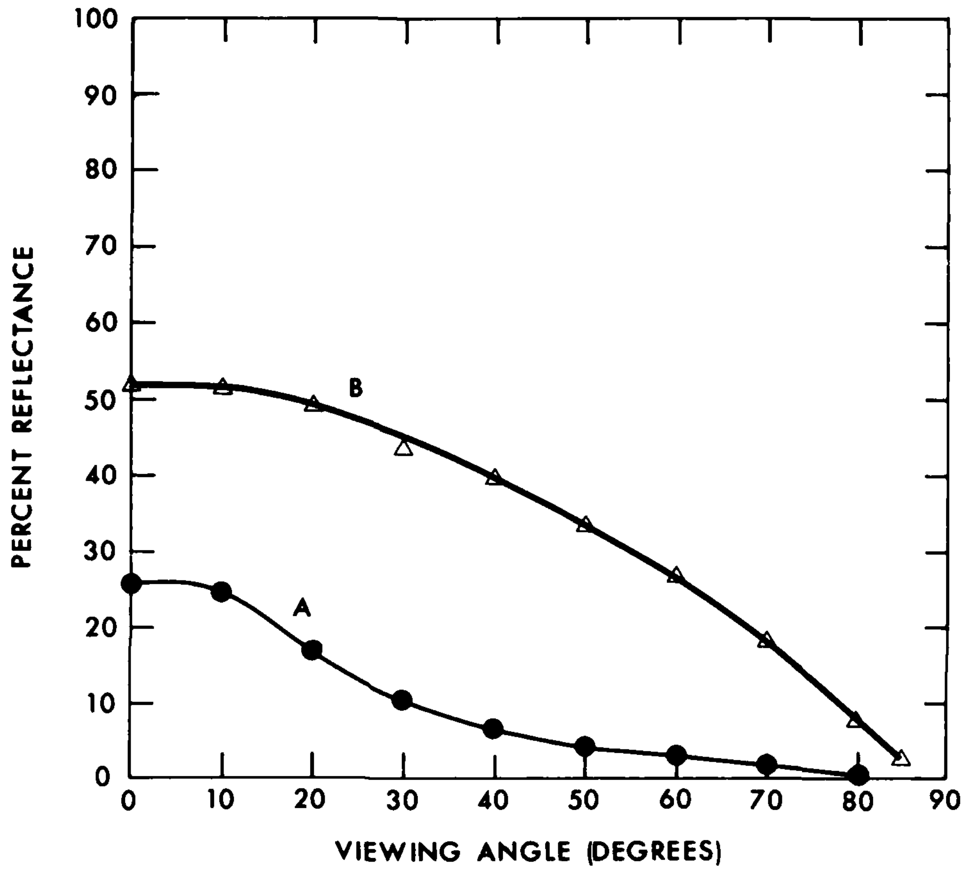

FIG. 4 - Reflectance of (A) painted target and (B) hessian-covered painted target as a function of viewing angle. Light was normally incident.

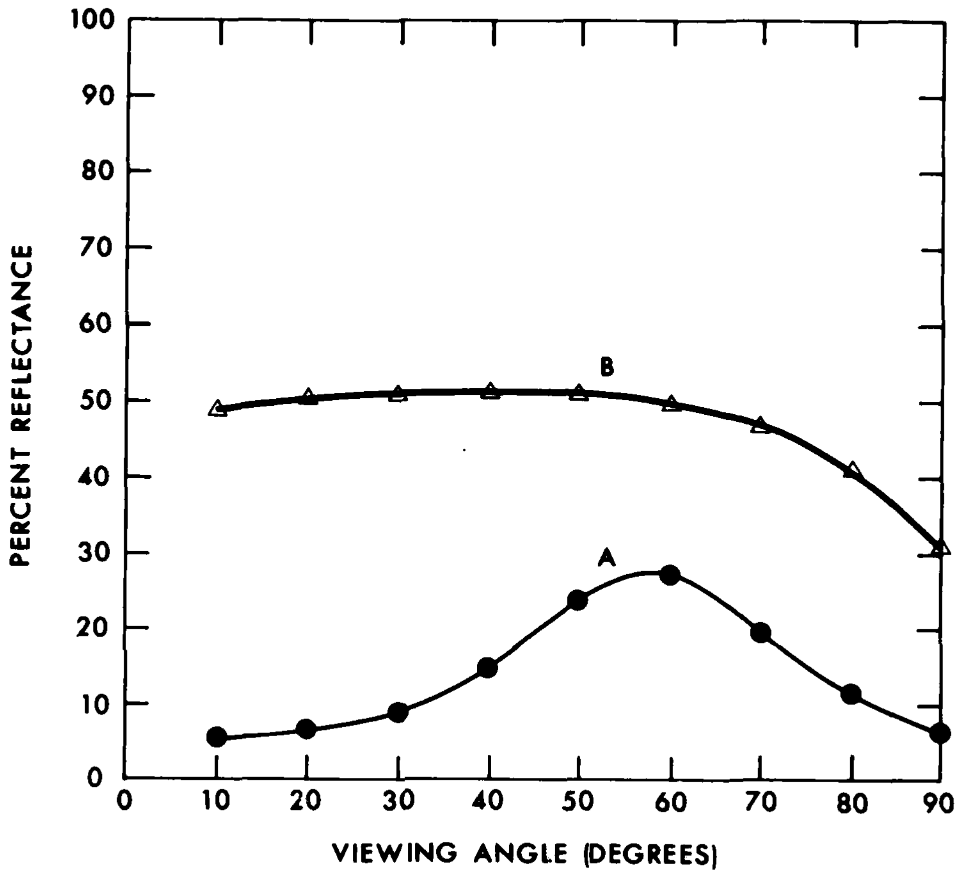

FIG. 5 - Reflectance of (A) painted target and (B) hessian-covered painted target as a function of viewing angle. Light was incident at 30° to the target surface normal.

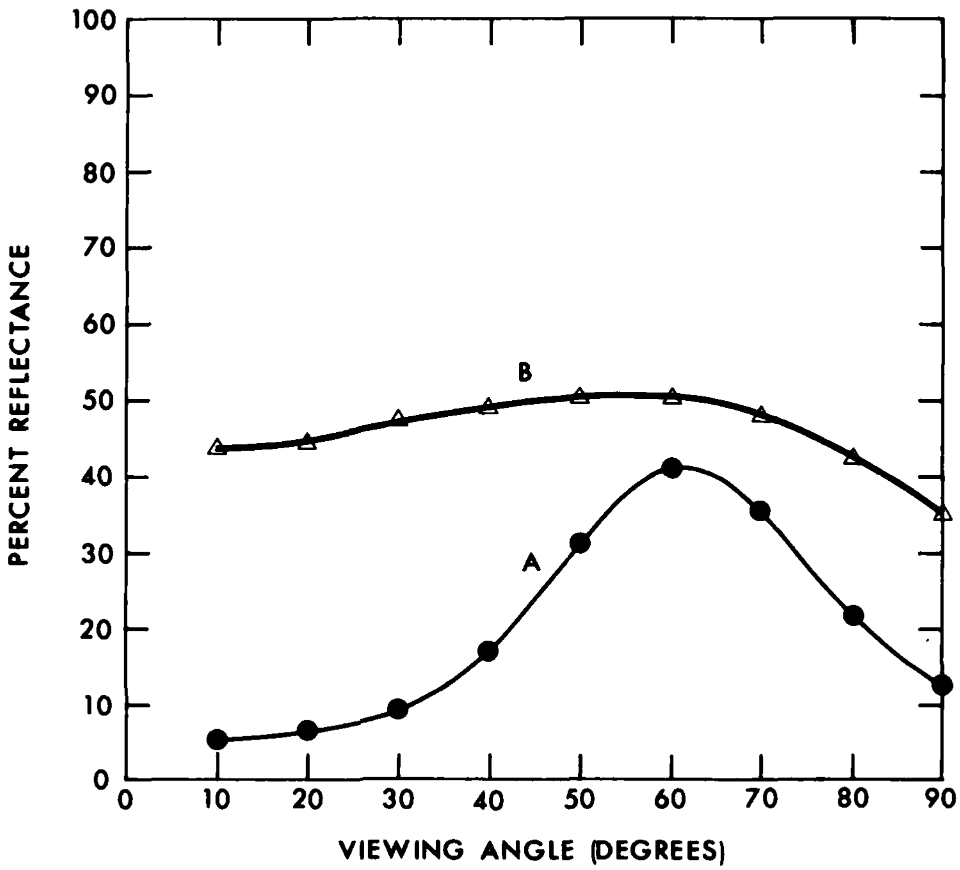

FIG. 6 - Reflectance of (A) painted target and (B) hessian-covered painted target as a function of viewing angle. Vertically polarised light was incident at 30° to the target surface normal.

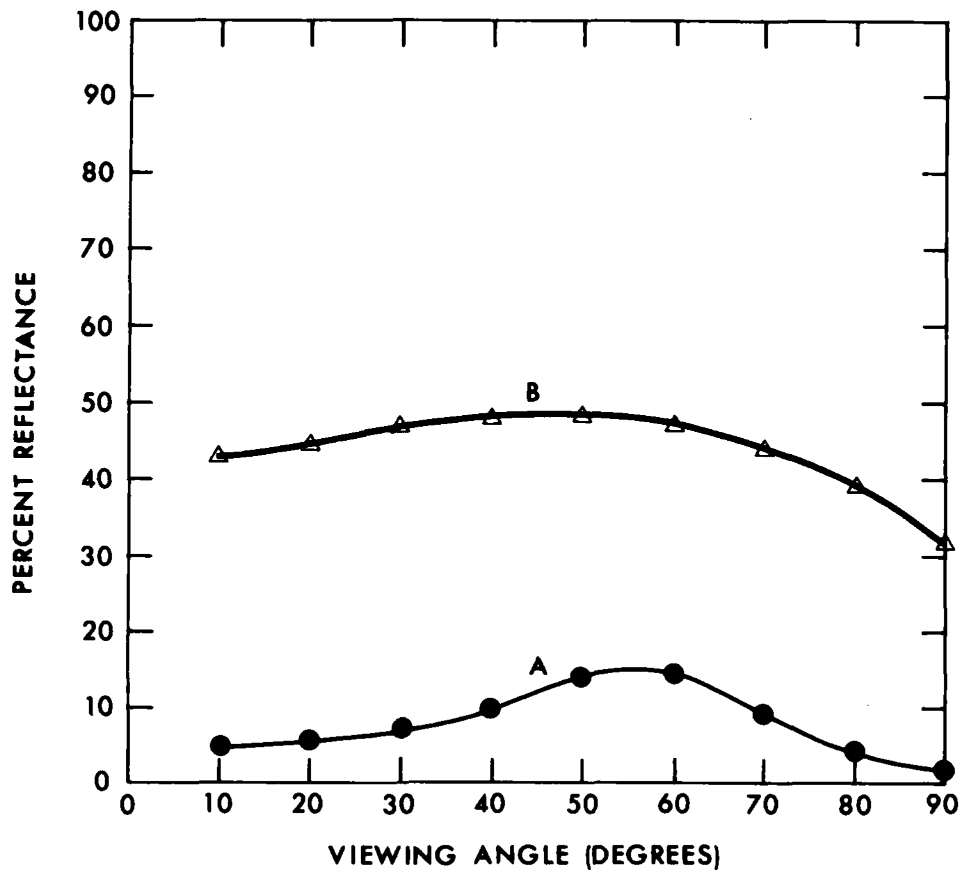

FIG. 7 - Reflectance of (A) painted target and (B) hessian-covered painted target as a function of viewing angle. Horizontally polarised light was incident at 30° to the target surface normal.

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